Northern Benguela upwelling:
Driving forces and ecosystem responses

Modeled vertical Carbon and Nitrogen fluxes in waters off Namibia

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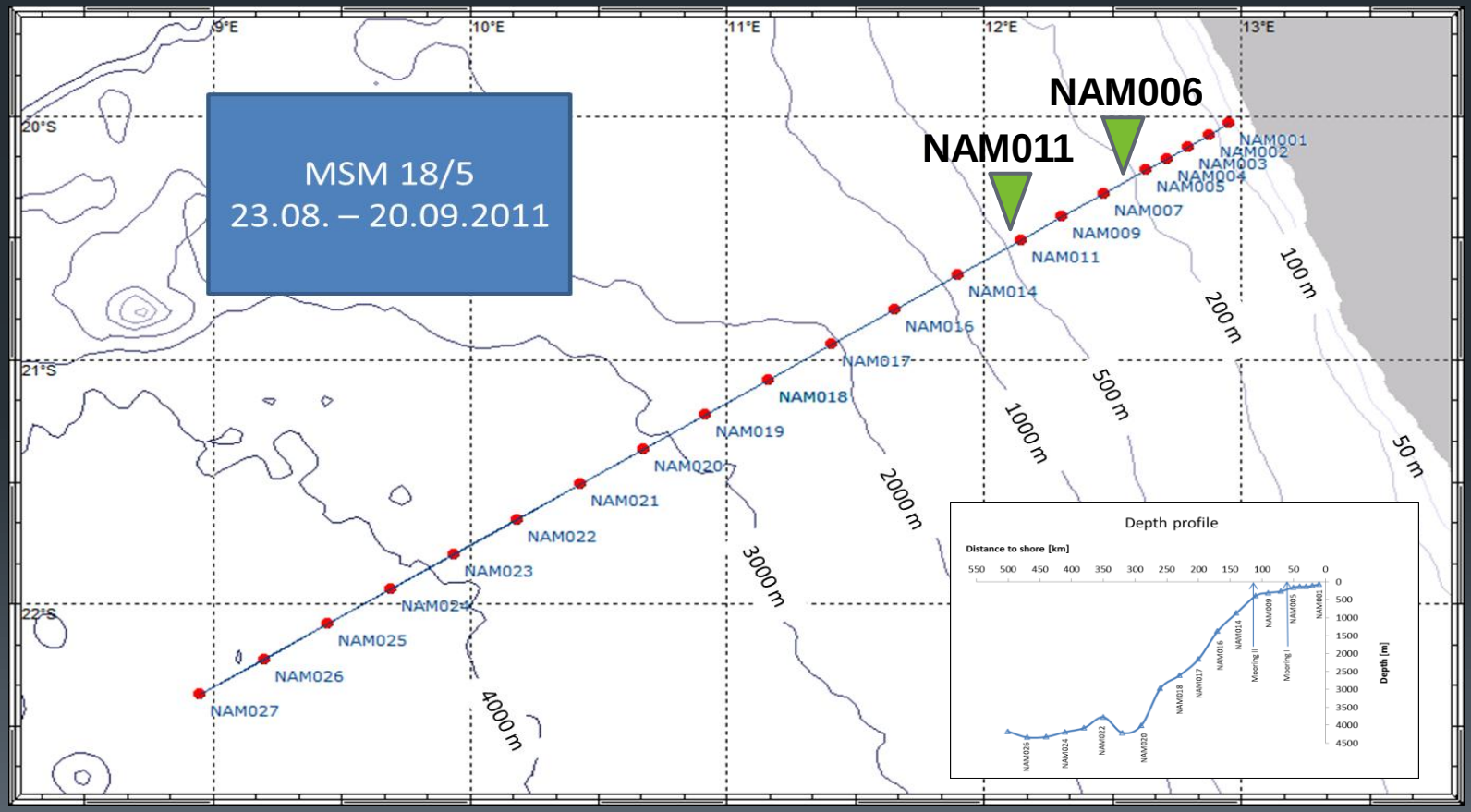
Benguela Upwelling

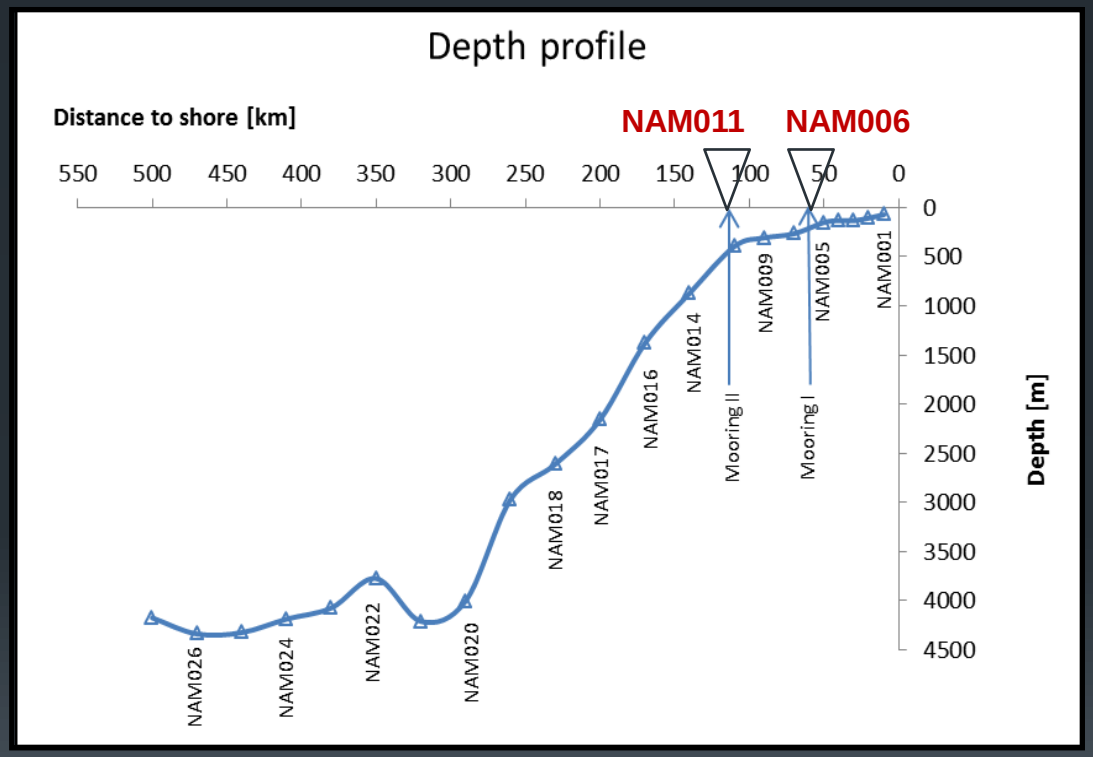
MSM 18/5

I. Mooring stations, NAM006 & NAM011

II. 3 Sections 12 ST & 1 Section 21 ST



I. Moorings Stations



NAM006

Date: 09/06/2011

Max. depth: 192 m.

Mooring depth: 170 m.

NAM011

Dates: 09/07/2011 and 09/17/2011

Max. depth: 395 m.

Mooring depth: 330 m.

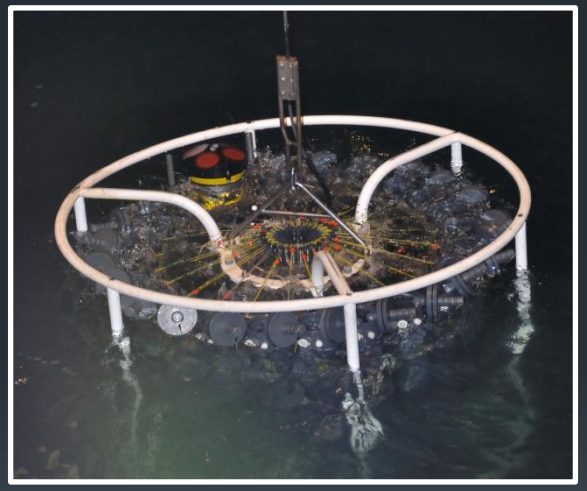
Sampling Methodology

Zooplankton

- ✓ 7 depths with the Multinet
- ✓ Size fractionation on board
- ✓ Cryovials frozen on liquid N_2

Microplankton

- ✓ 9 - 10 depths with the Rosette
- ✓ 4 - 6 liters of SW filtered on board
- ✓ Filters frozen on liquid N_2

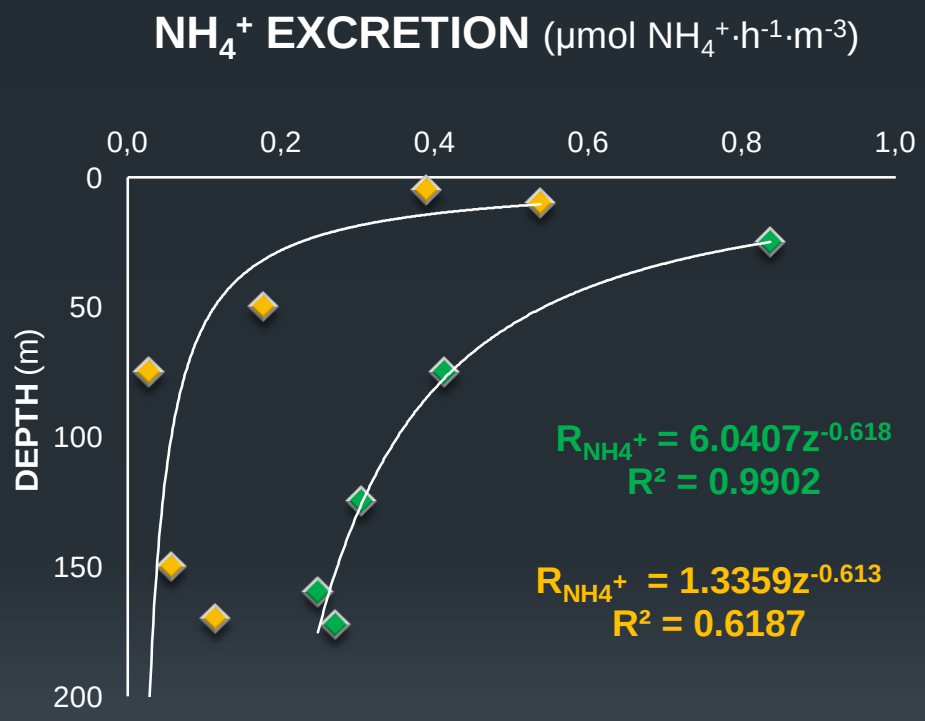


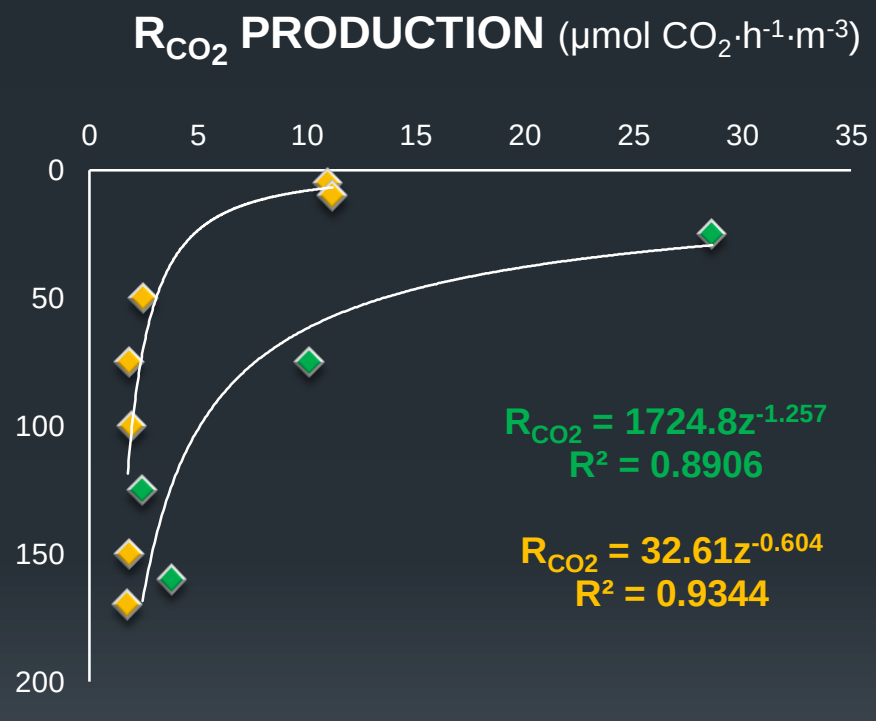
Back at lab,

- ➢ ETS and GDH activities (Packard et al., 1971; Bidigare and King, 1981)
- ➢ Protein content (Lowry, 1951)

Results

NAM006





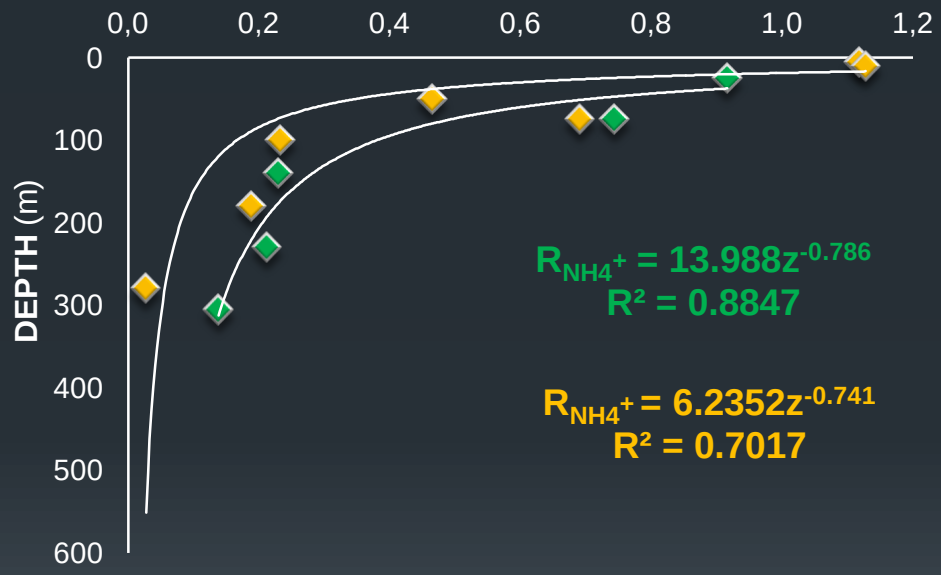
♦ Microplankton ♦ Zooplankton

At the 3 stations, the b-value is higher in zooplankton than in microplankton.

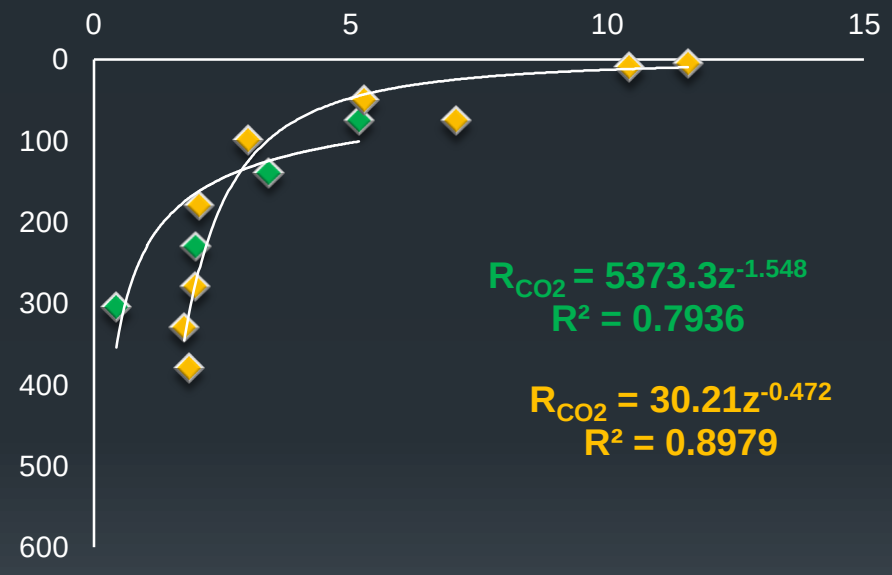
Results

NAM011 (7 Sept.)

NH_4^+ EXCRETION (µmol $NH_4^+ \cdot h^{-1} \cdot m^{-3}$)



R_{CO_2} PRODUCTION (µmol $CO_2 \cdot h^{-1} \cdot m^{-3}$)



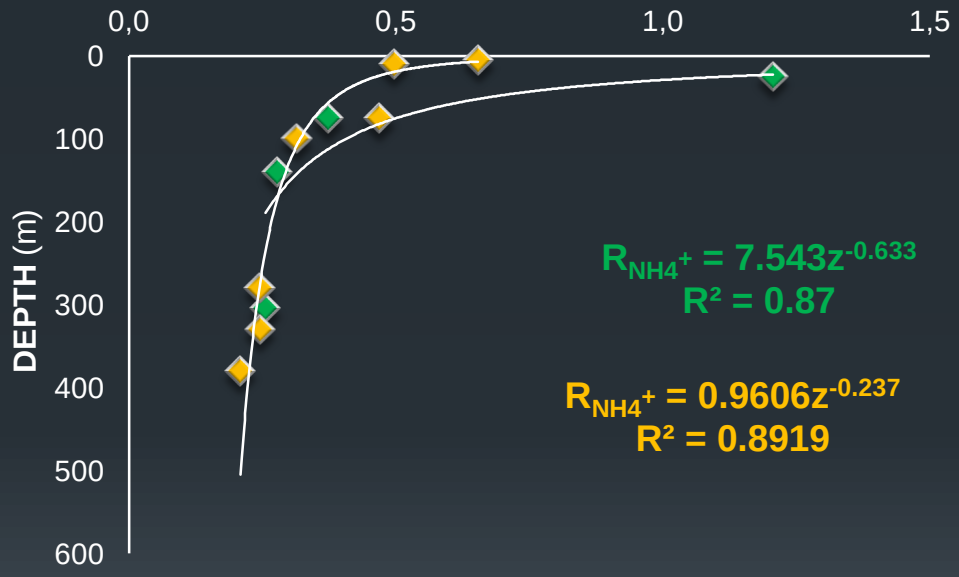
♦ Microplankton ♦ Zooplankton

At the 3 stations, the b-value is higher in zooplankton than in microplankton.

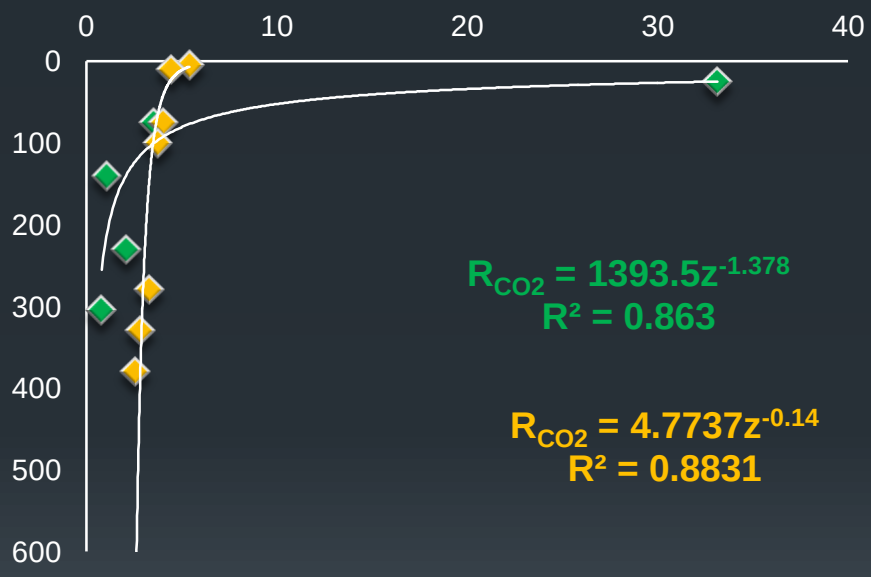
Results

NAM011 (17 Sept.)

NH_4^+ EXCRETION (µmol $NH_4^+ \cdot h^{-1} \cdot m^{-3}$)



R_{CO_2} PRODUCTION (µmol $CO_2 \cdot h^{-1} \cdot m^{-3}$)



♦ Microplankton ♦ Zooplankton

At the 3 stations, the b-value is higher in zooplankton than in microplankton.

Results

- Calculate the definite integral from the different depths (z_a) to the sea floor (z_s)

Nitrogen

$$F_n = \int R_{NH4^+}\, dz = \int R_0 z^{-b}$$

$$F_n = (R_0/(1-b))*(z_s^{(1-b)} - z_a^{(1-b)})$$

Carbon

$$F_c = \int R_{CO2}\, dz = \int R_0 z^{-b}$$

$$F_c = (R_0/(1-b))*(z_s^{(1-b)} - z_a^{(1-b)})$$

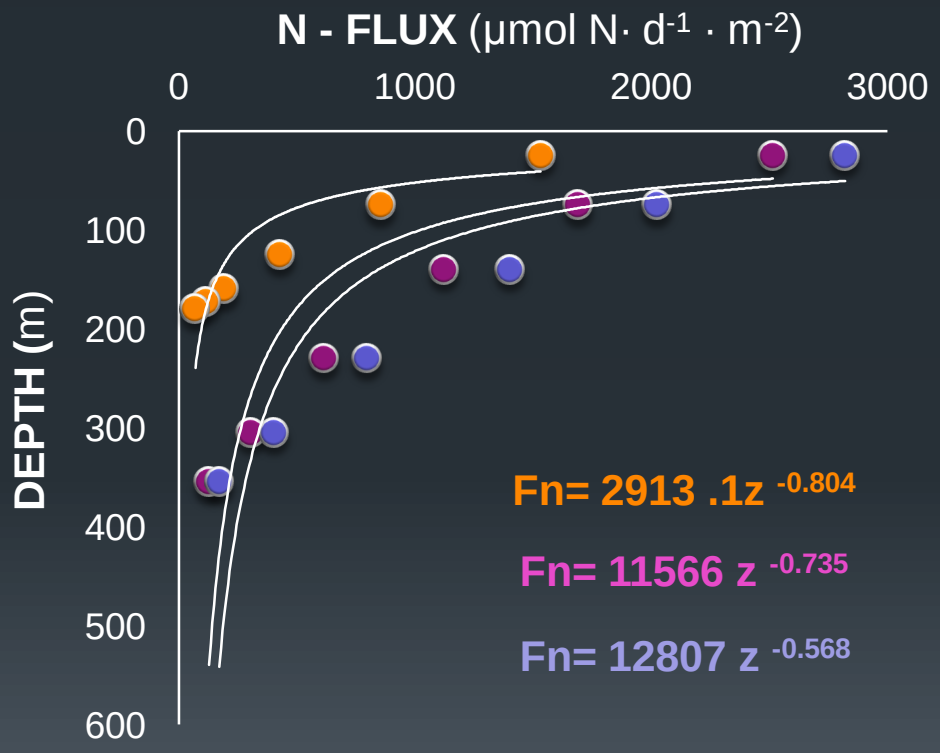
- Plot Fn and Fc versus depth

Results

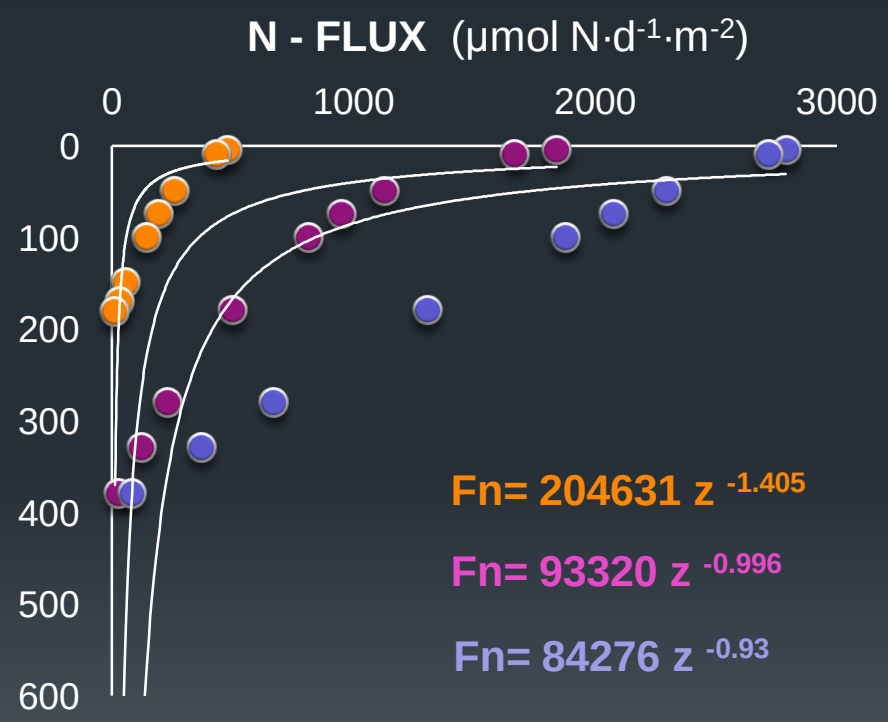
Moorings stations

Nitrogen

Zooplankton



Microplankton



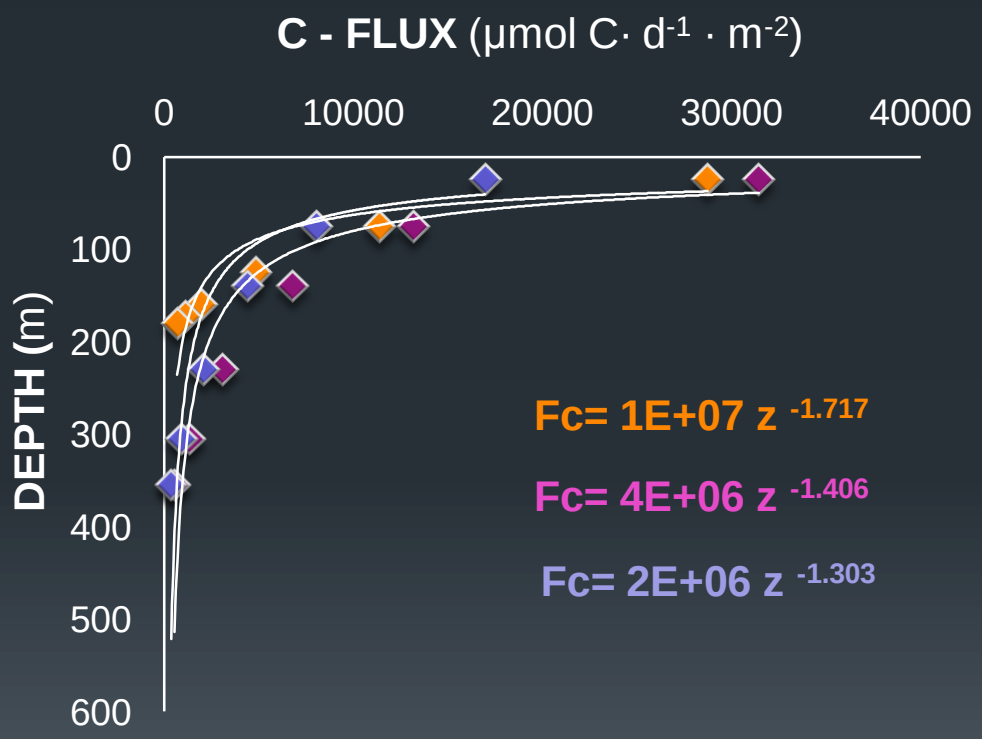
● NAM006 ● NAM011 (7 Sept.) ● NAM011 (17 Sept.)

Results

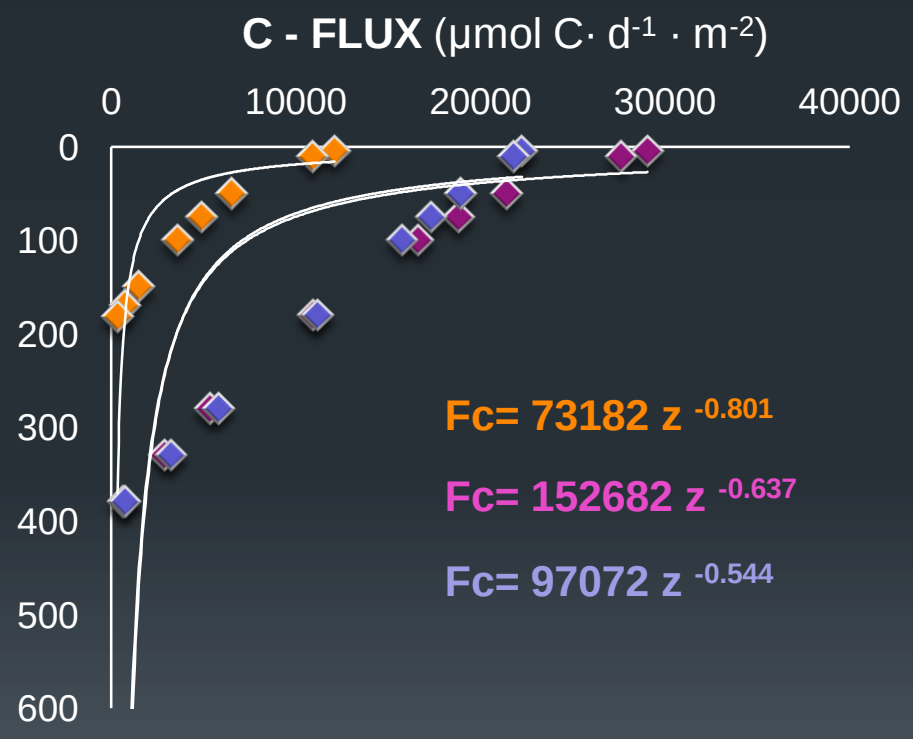
Moorings stations

Carbon

Zooplankton



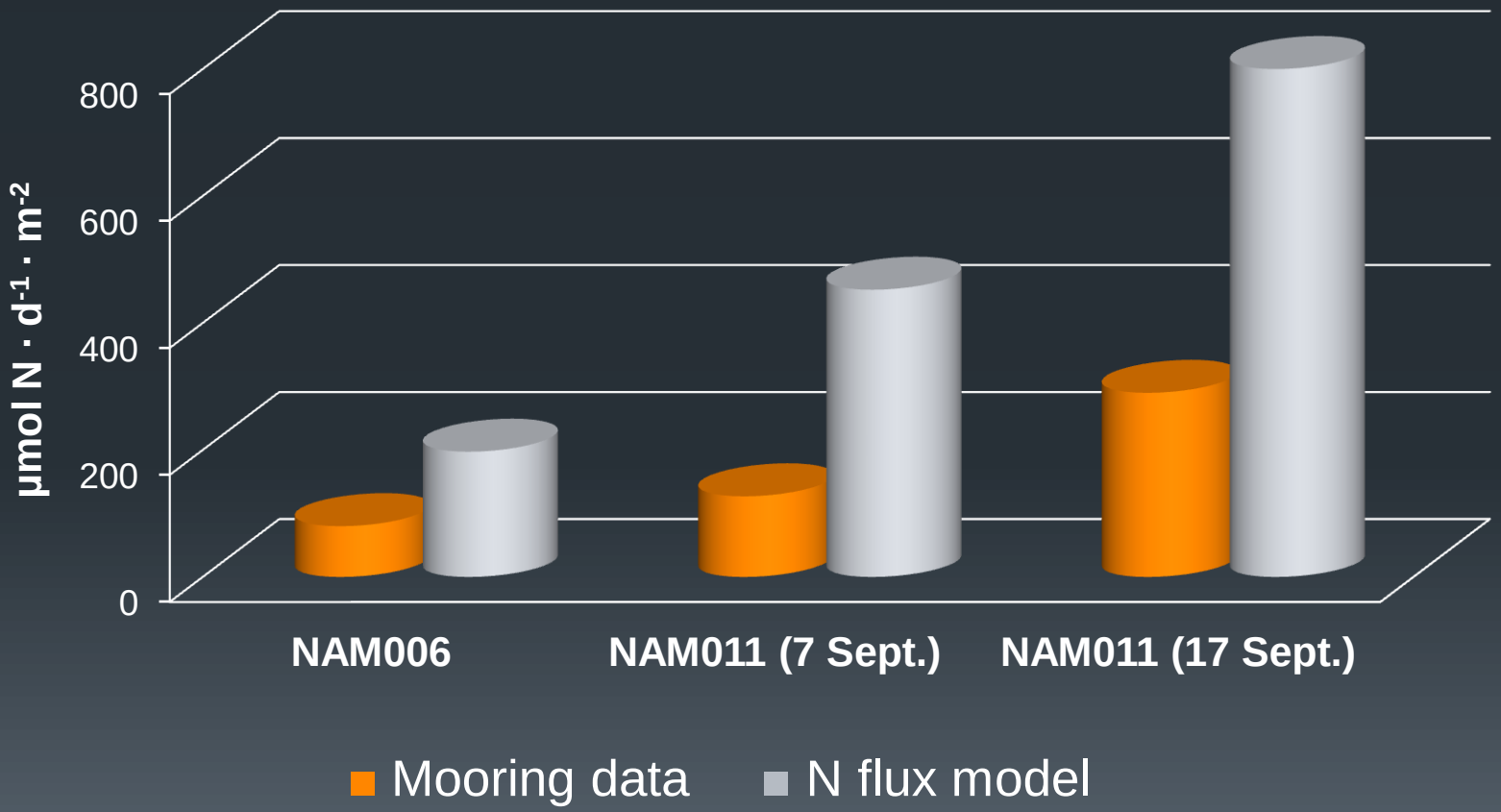
Microplankton



● NAM006 ● NAM011 (7 Sept.) ● NAM011 (17 Sept.)

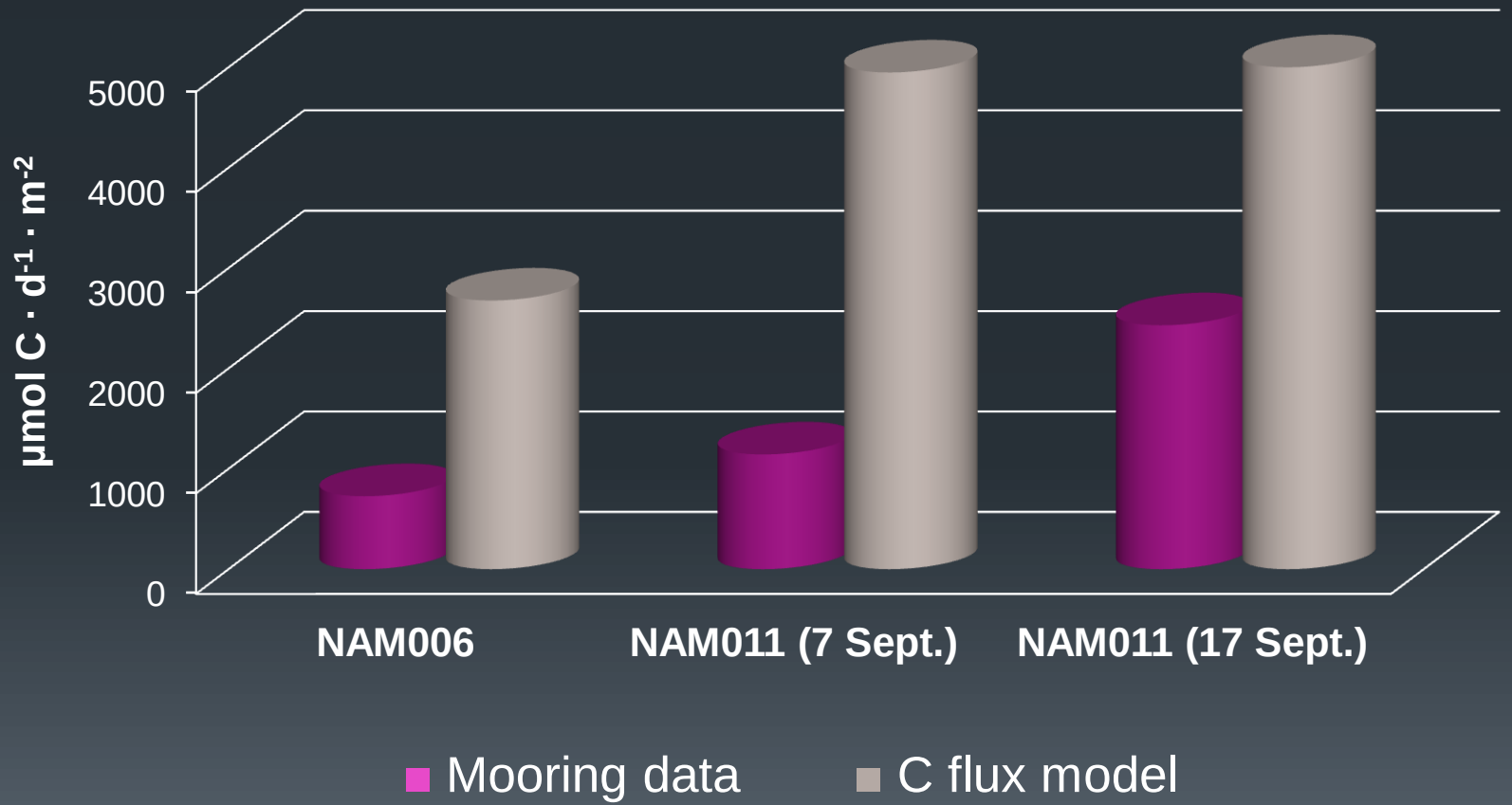
Results

Total Nitrogen Fluxes



Results

Total Carbon Fluxes

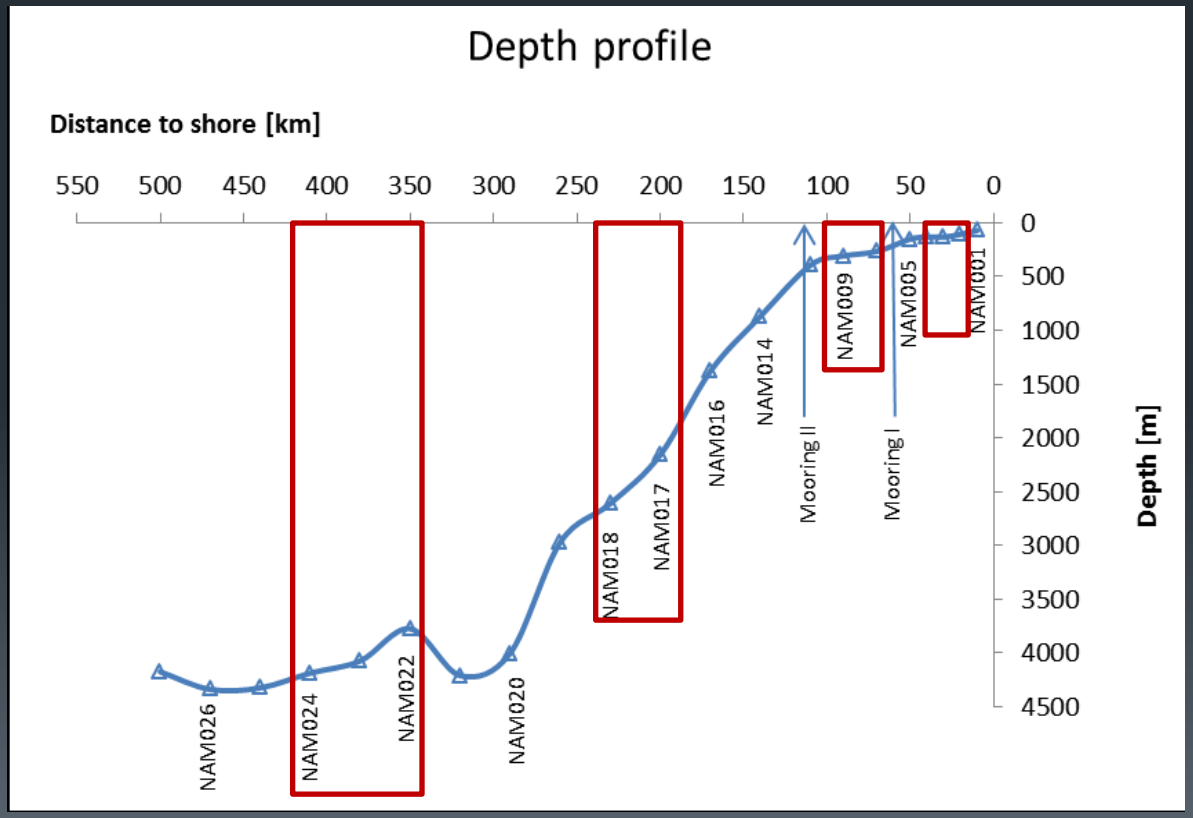


Summary I

Carbon and nitrogen fluxes calculated from total plankton respiration and ammonium excretion greatly exceeds fluxes calculated from sediment trap measurements (Packard and Christensen, 2004; Steinberg, 2008; Packard and Gómez, submitted)

II. Sections: *Nitrogen*

Zooplankton associated N fluxes, based on average values of GDH activities on the 4 sections. Comparison of 4 areas within the section.



NAM002 & 003

NAM007 & 009

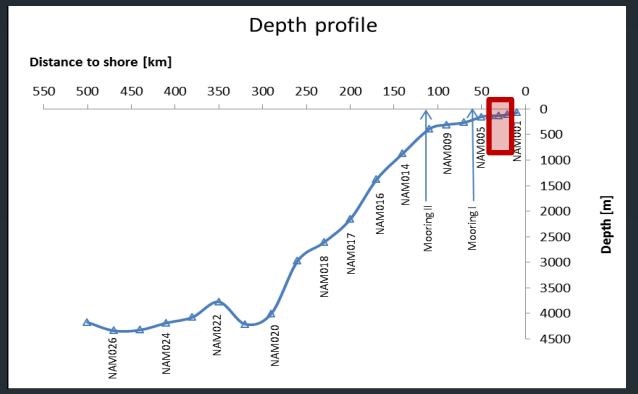
NAM017 & 018

NAM022 & 024

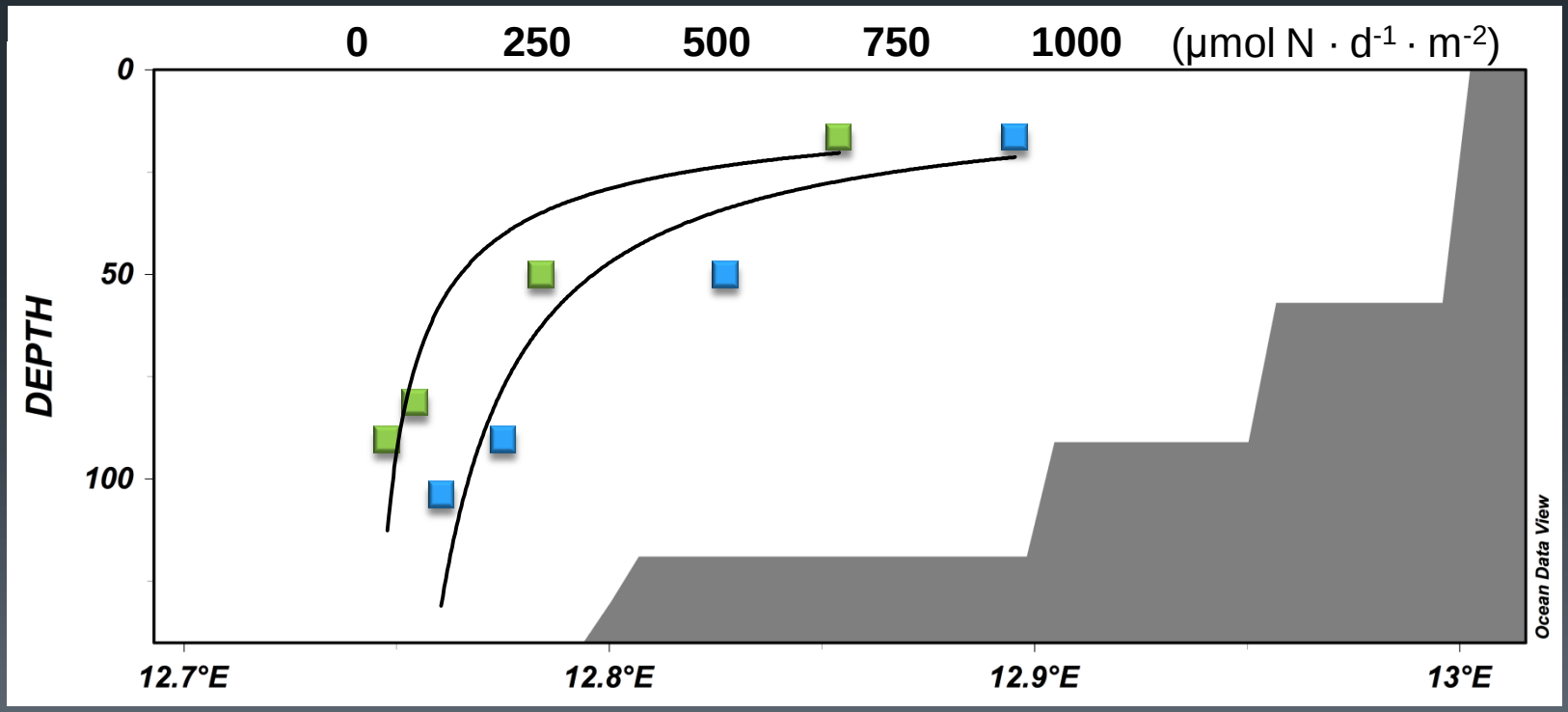
Results: *Nitrogen*

NAM002 $Fn = 18463\ z^{-1.24}$

NAM003 $Fn = 9509\ z^{-0.861}$



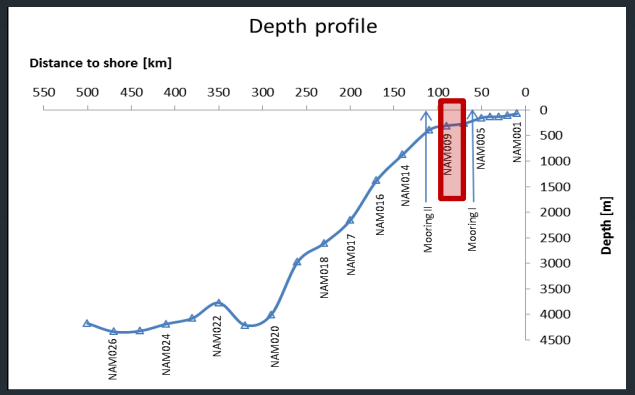
N - FLUX



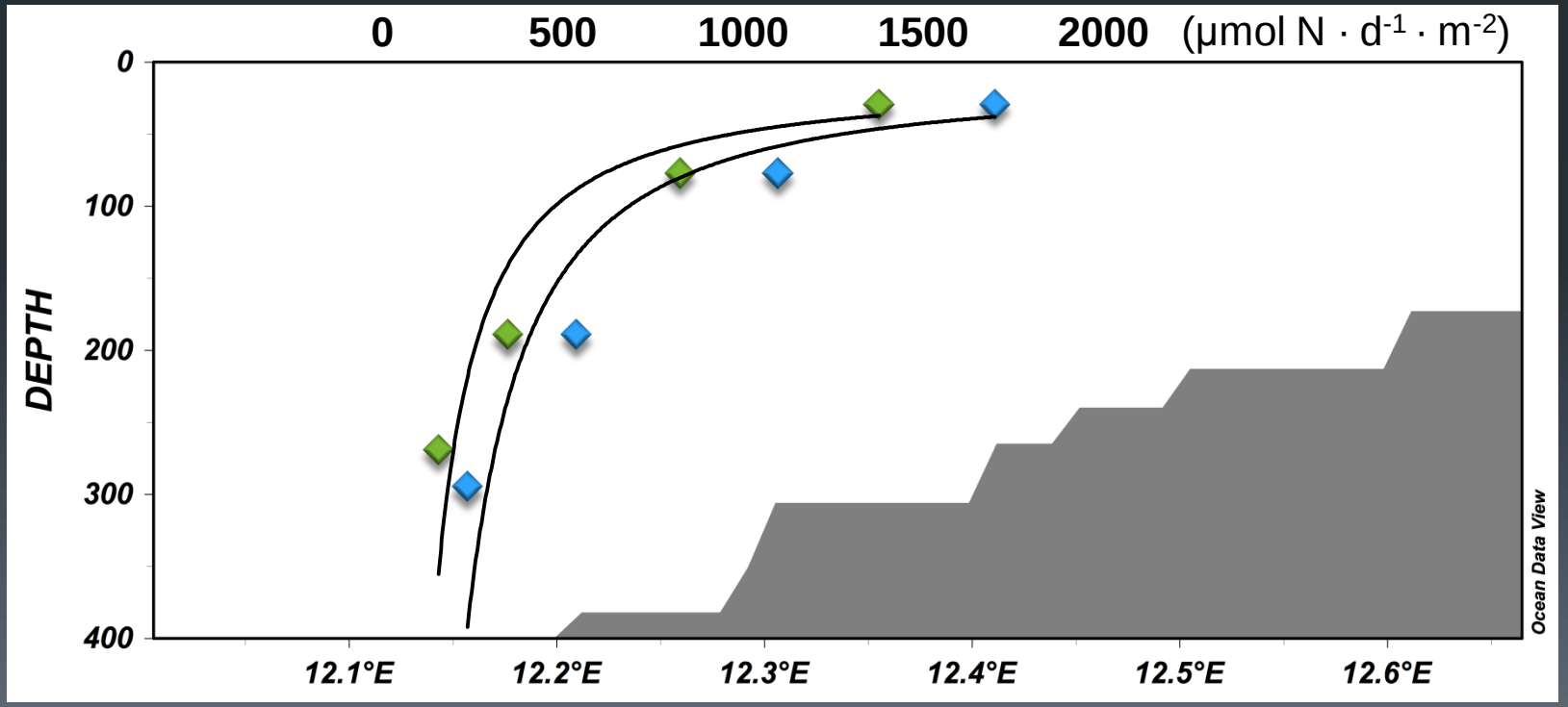
Results: *Nitrogen*

NAM007 $Fn = 10636\ z^{-0.735}$

NAM009 $Fn = 10292\ z^{-0.643}$



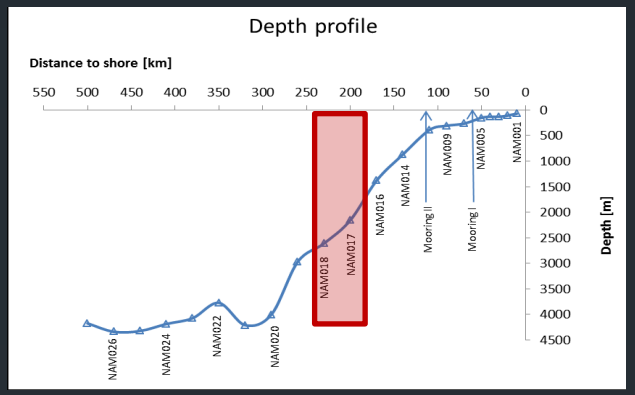
N - FLUX



Results: *Nitrogen*

NAM017 $Fn = 10197\ z^{-0.403}$

NAM018 $Fn = 14682\ z^{-0.393}$



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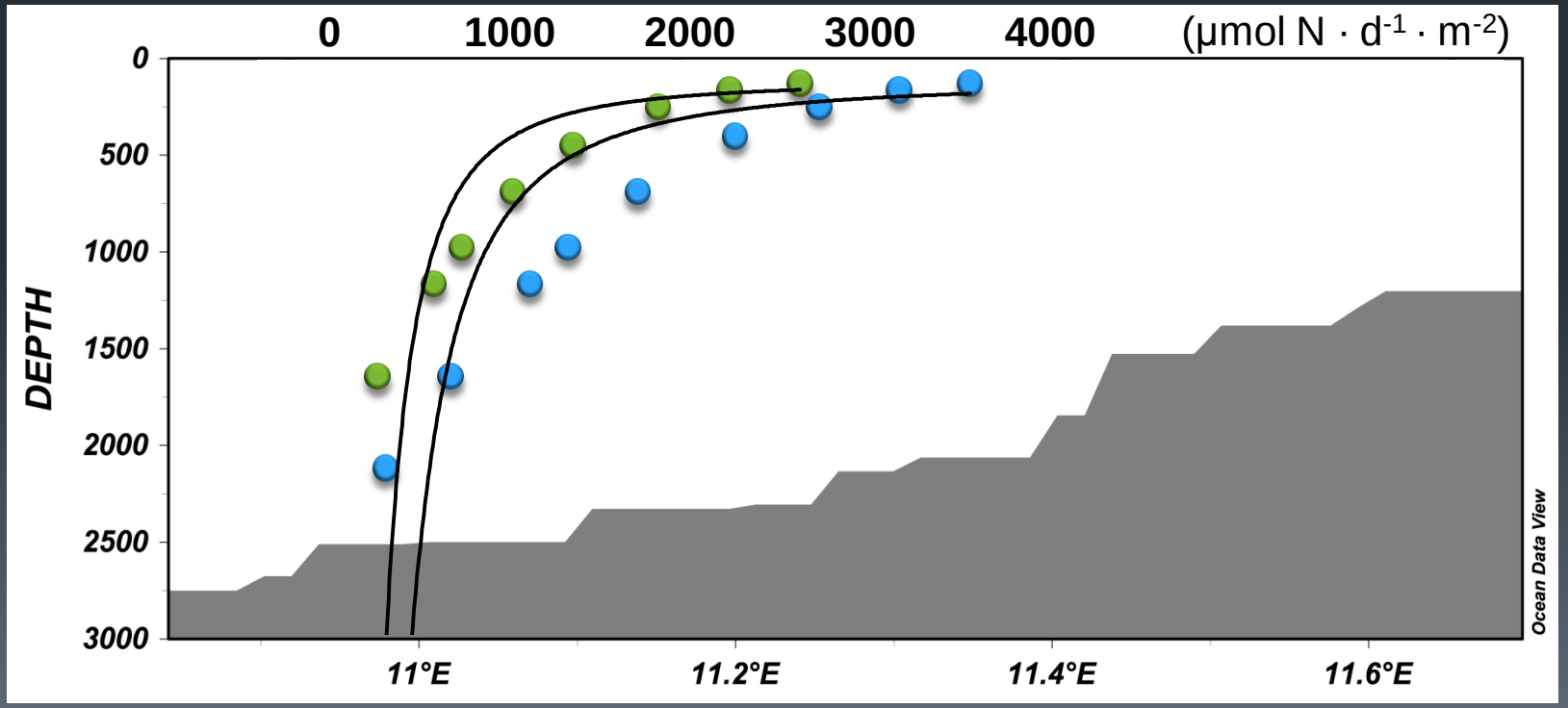
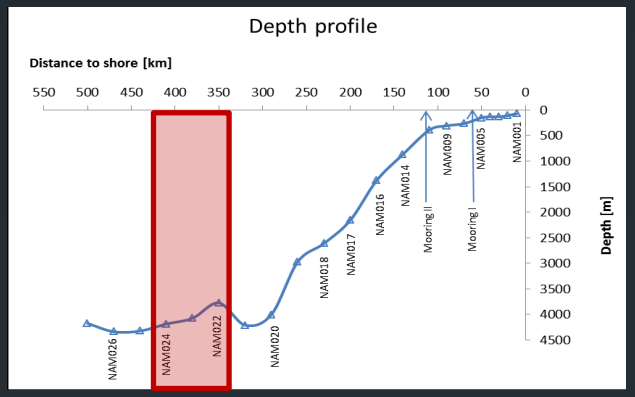


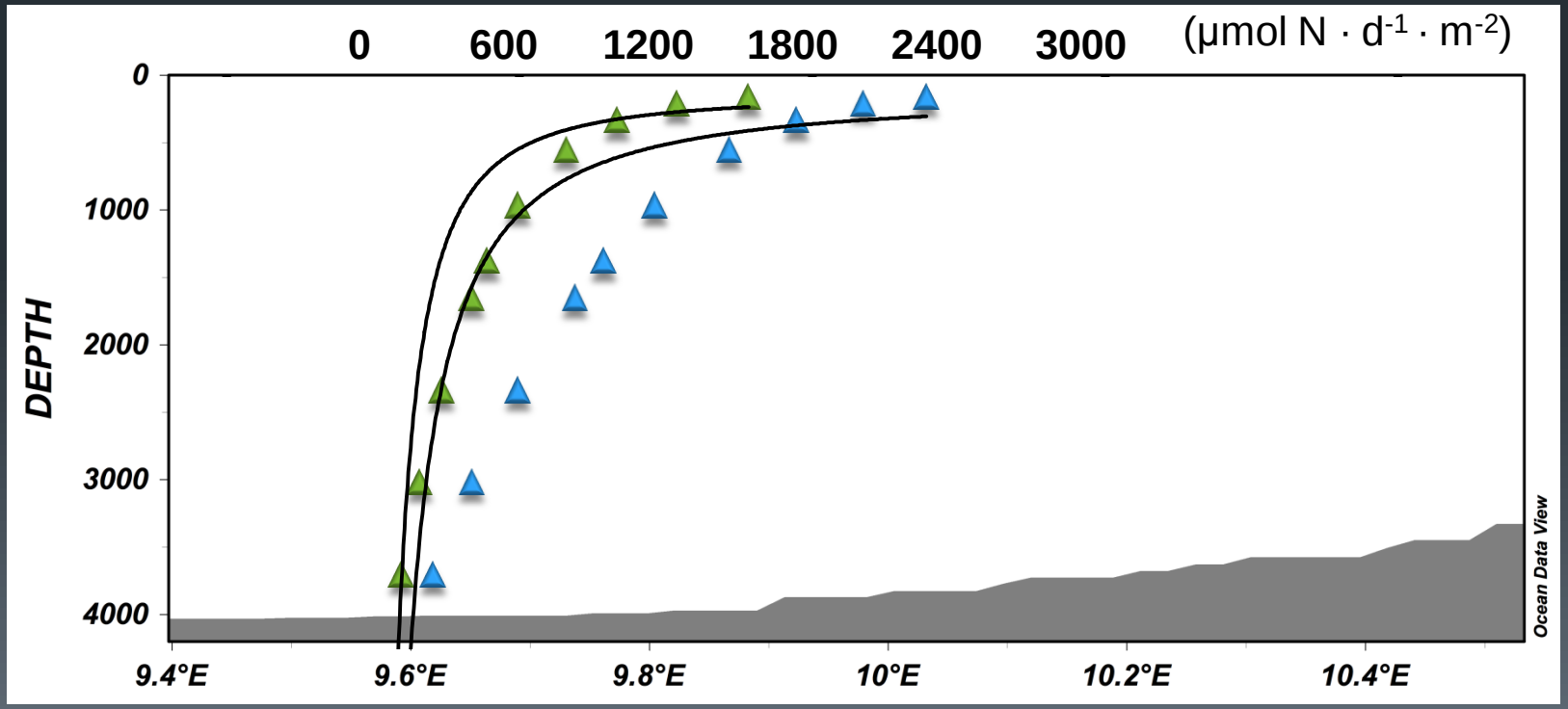
Results: *Nitrogen*

NAM022 $Fn = 14414\ z^{-0.464}$

NAM024 $Fn = 8862.8\ z^{-0.469}$

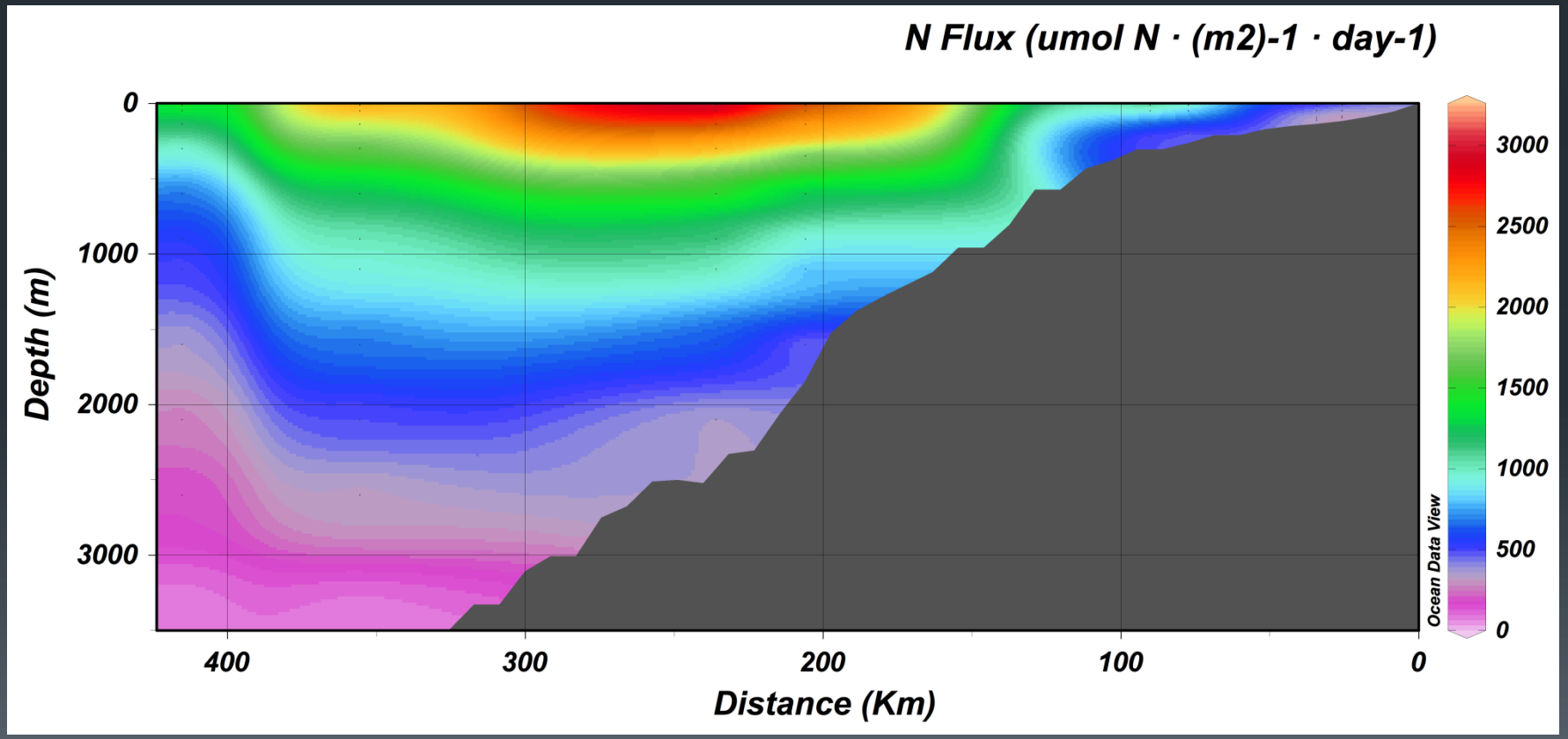


N - FLUX



Results: *Nitrogen*

Zooplankton associated N flux profile along the section



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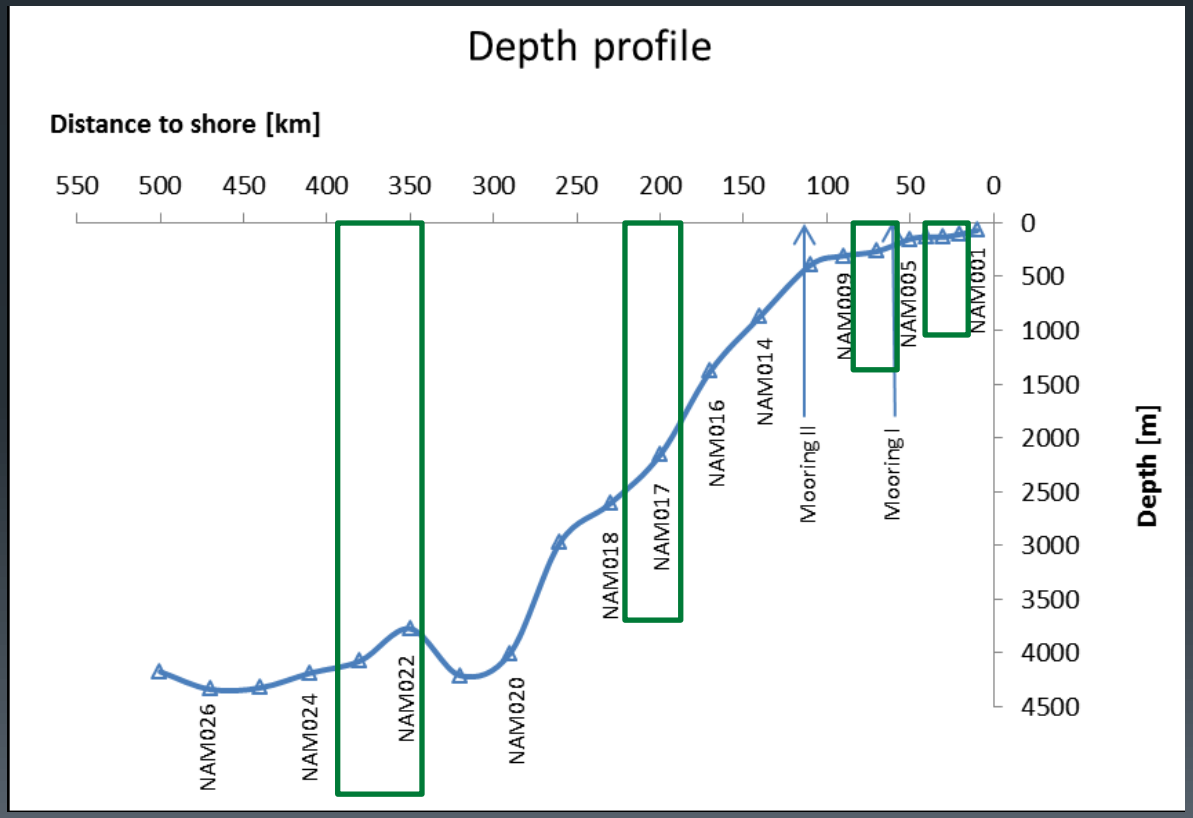
Zooplankton associated C fluxes, based on average values of ETS activities on the 4 sections. Comparison of 4 areas within the section.



NAM002 & 003

NAM007

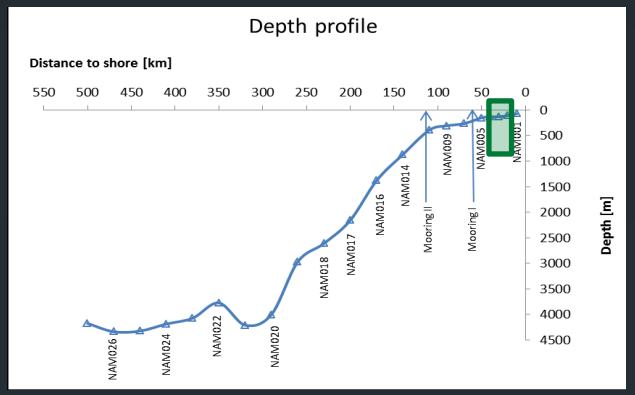
NAM017

NAM022 & 023

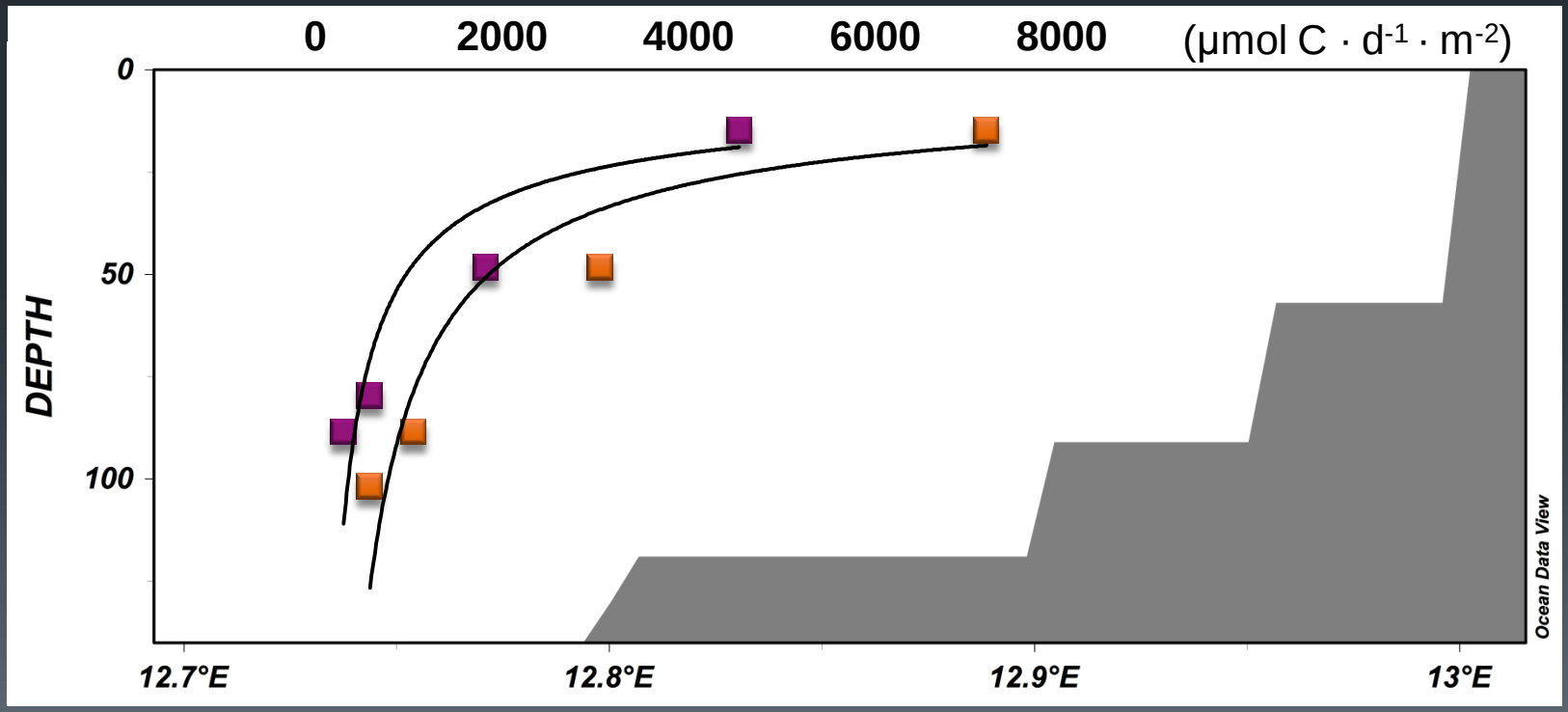
Results: *Carbon*

NAM002 $Fc = 114045\ z^{-1.203}$

NAM003 $Fc = 126793\ z^{-1.069}$

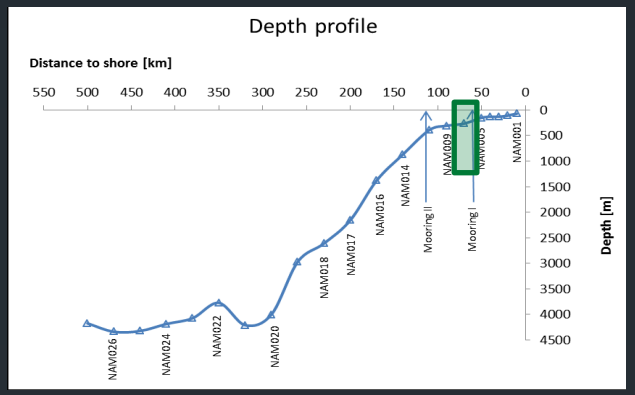


C - FLUX

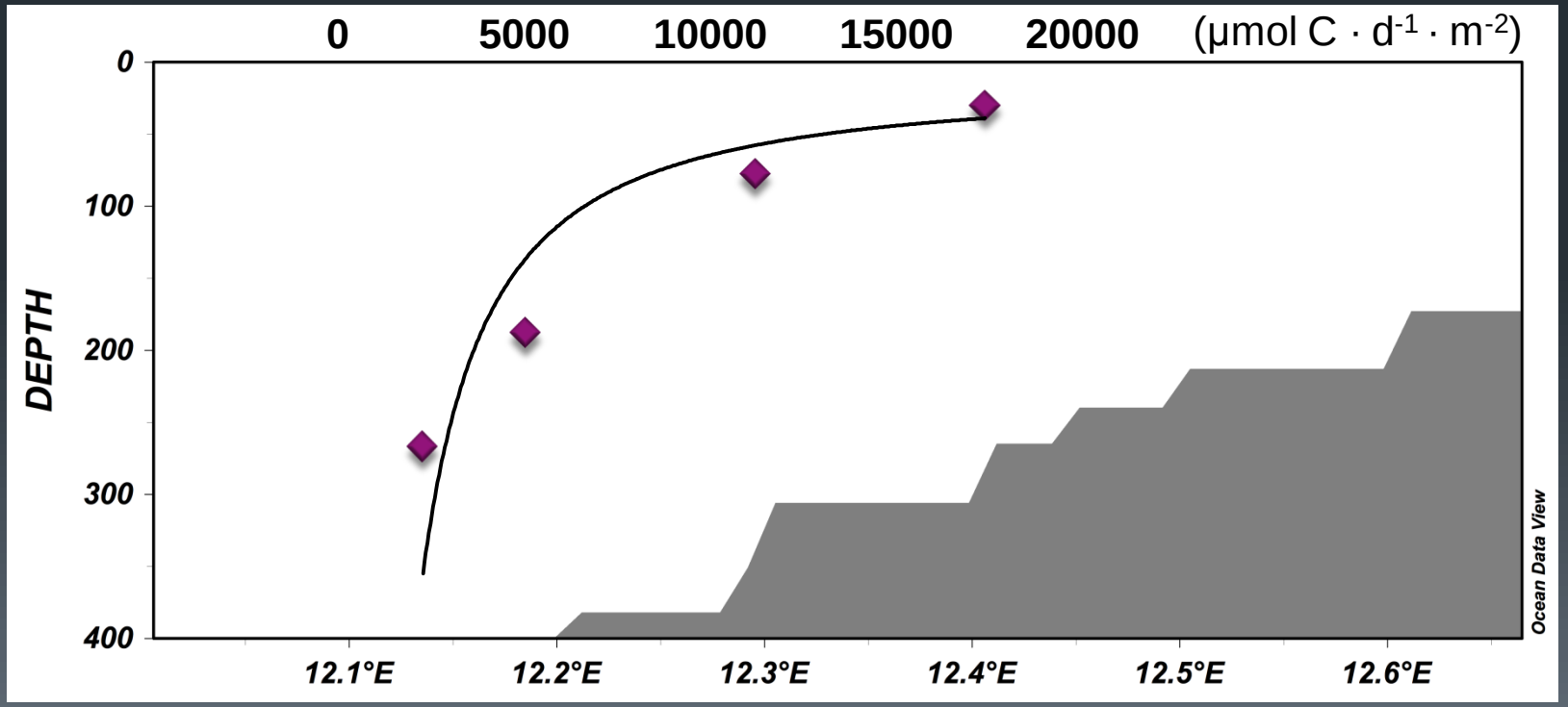


Results: *Carbon*

NAM007 $Fc = 116264\ z^{-0.679}$

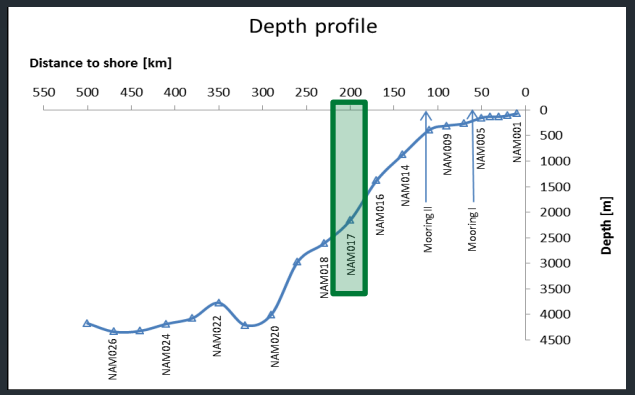


C - FLUX

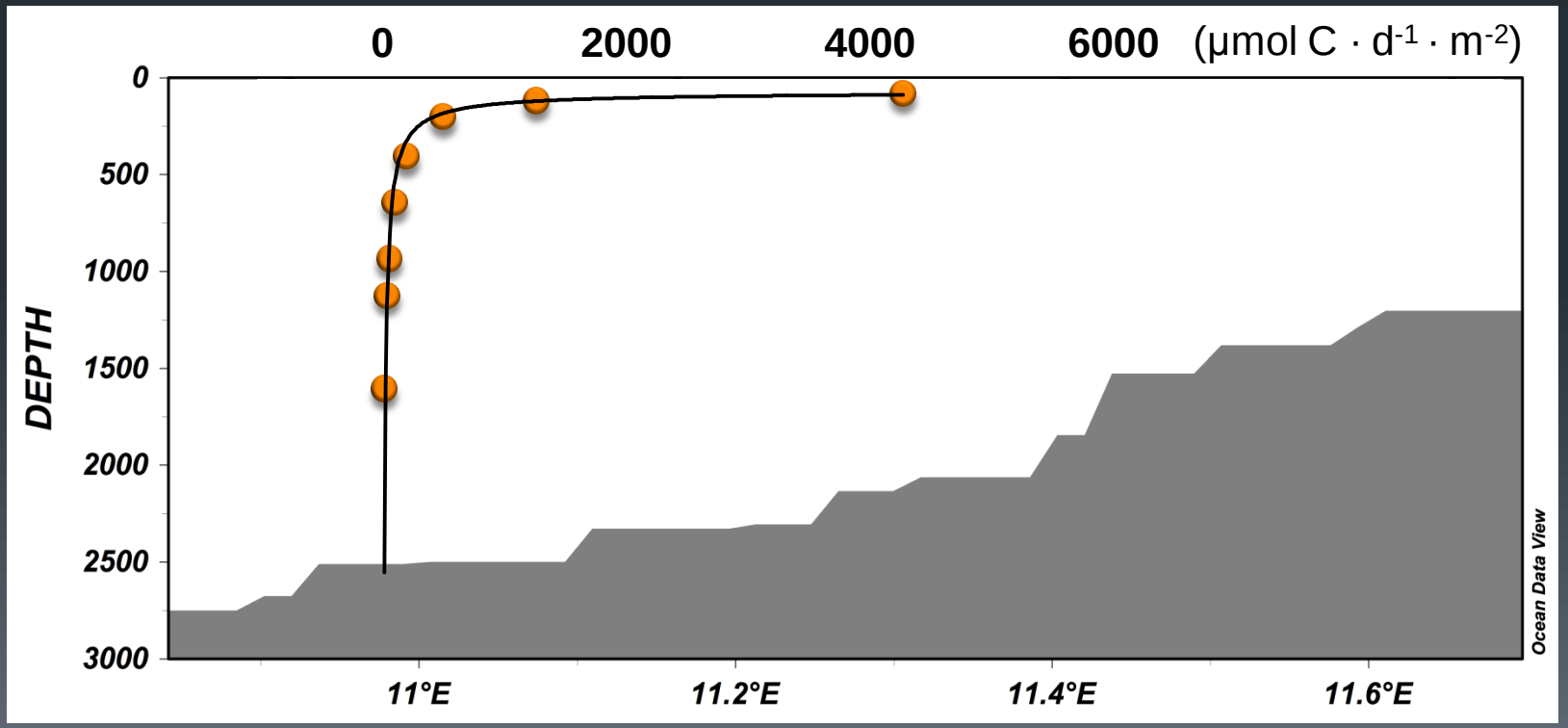


Results: *Carbon*

NAM017 $Fc = 90231\ z^{-1.098}$



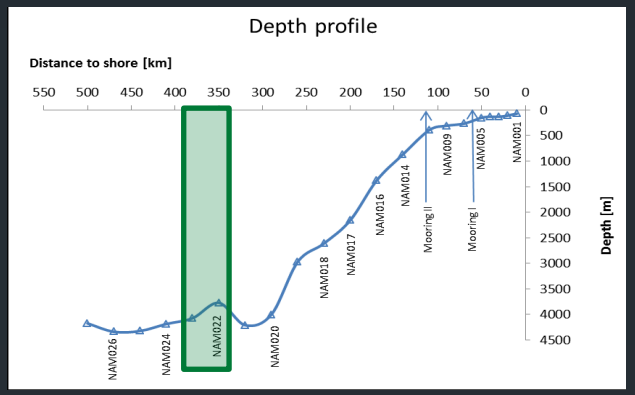
C - FLUX



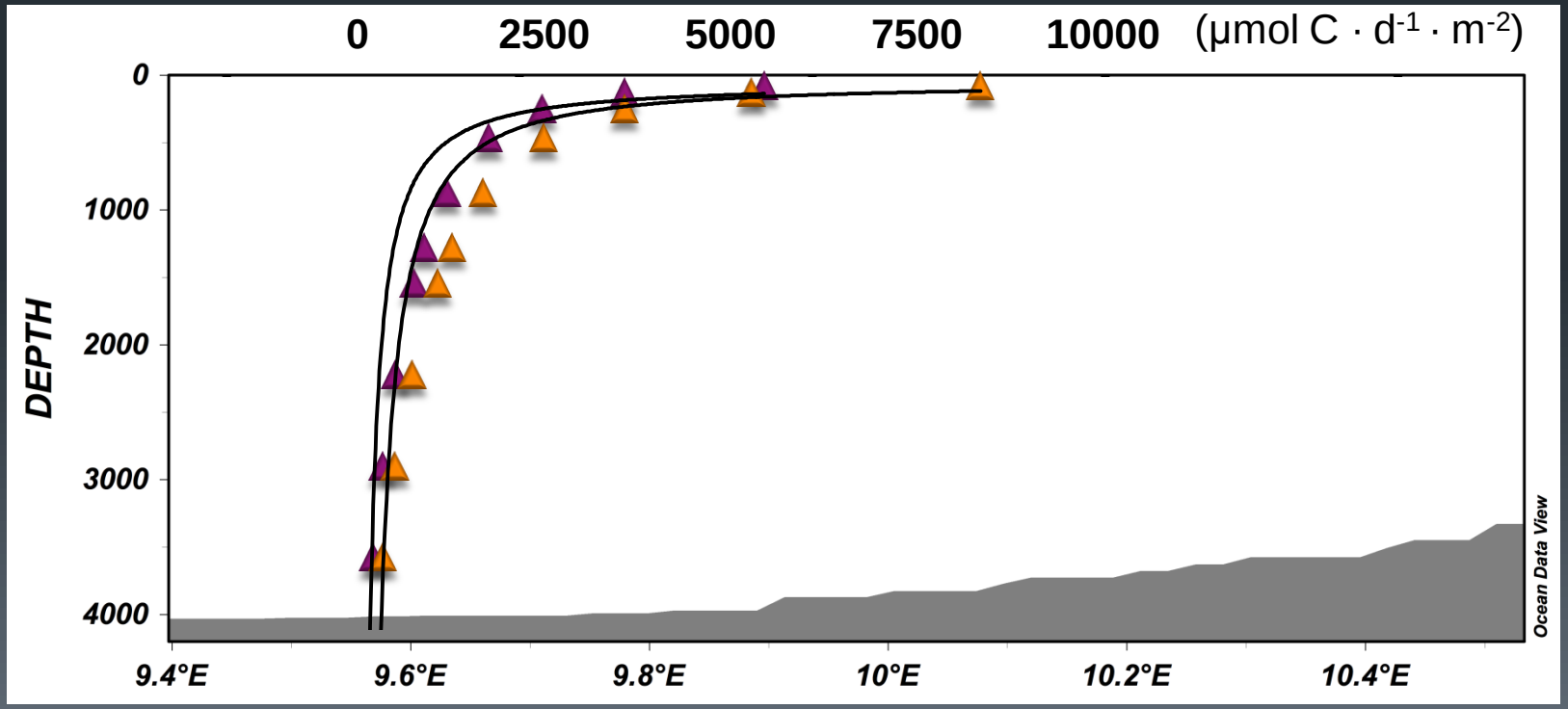
Results: *Carbon*

NAM022 $Fc = 60173\ z^{-0.693}$

NAM023 $Fc = 75534\ z^{-0.66}$

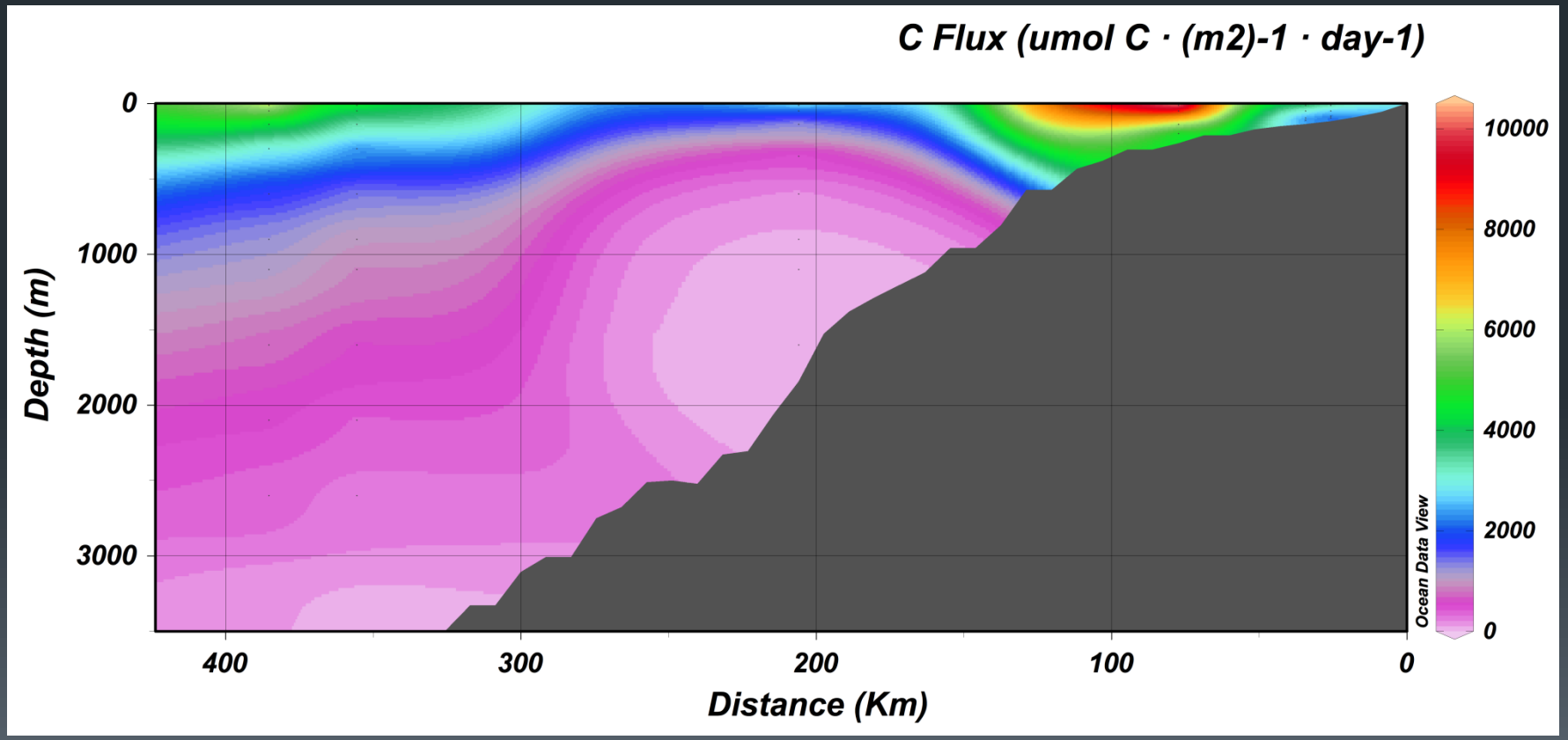


C - FLUX



Results: *Carbon*

Zooplankton associated C flux profile along the section



Results: Nitrogen & *Carbon*

- The exponent of the power function (b value) were HIGHER on the onshore stations than on the offshore stations.

b- values	**NAM002**	**NAM003**	**NAM007**	**NAM009**	**NAM017**	**NAM018**	**NAM022**	**NAM023**	**NAM024**
Nitrogen Flux	1.24	0.861	0.735	0.643	0.403	0.393	0.464	---	0.469
Carbon Flux	1.203	1.069	0.679	---	1.098	---	0.693	0.660	---

- Nutrient transfer efficiency (Teff) and nutrient retention efficiency (NRE) are directly related with the profile curvature (b value).

Results: Carbon

- Calculations of the Carbon transfer efficiency (Teff) and the nutrient retention efficiency (NRE) for the offshore stations. (Buesseler et al., 2007)

$$T_{eff} = (Fc_{500} / Fc_{150}) \cdot 100$$

$$NRE = [(Fc_{150} – Fc_{500}) / Fc_{150}] \cdot 100$$

Station	C- FLUX 150m	C- FLUX 500m	Teff %	NRE %
NAM017	368.14	98.15	**26.66**	**73.34**
NAM022	1867.97	810.99	**43.42**	**56.58**
NAM023	2766.45	1249.75	**45.18**	**54.82**

- Teff < 60% indicate high respiration rates between this depths.

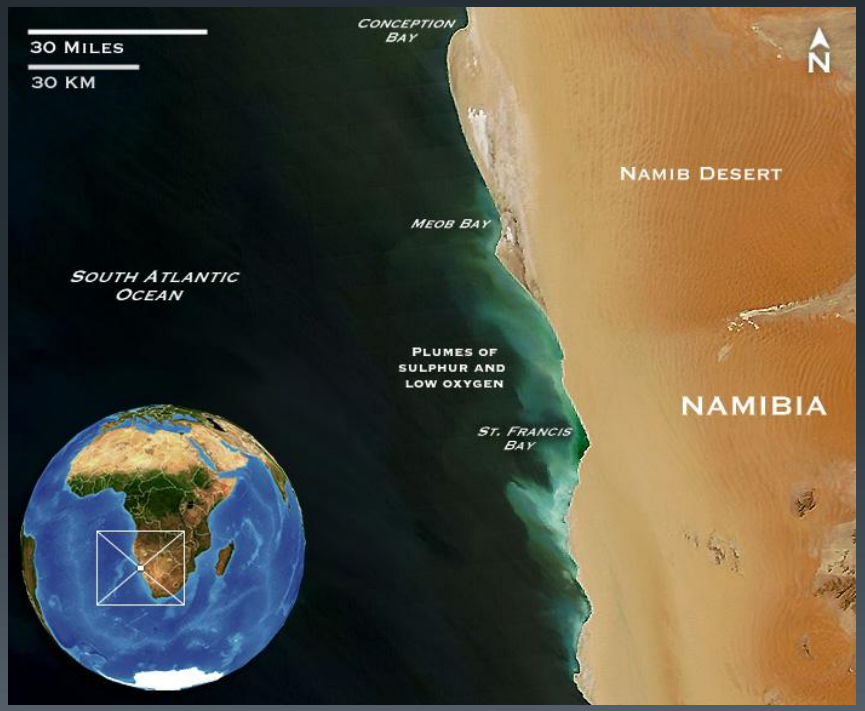
Summary II

- Carbon flux values were higher at the onshore stations while the highest values of nitrogen fluxes were found at a middle position in the section.

- Carbon transfer efficiency and nutrient retention efficiency show high respiration rates in this mesopelagic waters.

Aknowledgement

We are grateful to all the institutions which made the SUCCESSION Project possible, and specially to Dr. Postel for providing us the tools to develop the present work.



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MSM 18
Subtropical & Tropical Atlantic
Physical & Biogeochemical Studies
IOW — IFM-GEOMAR — MARUM

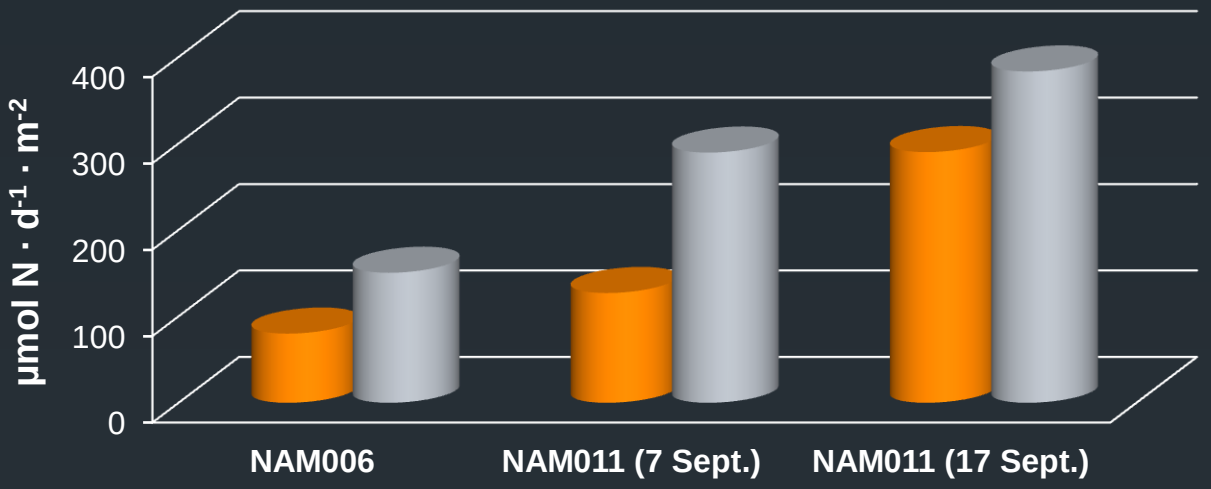
Additional Information

Results

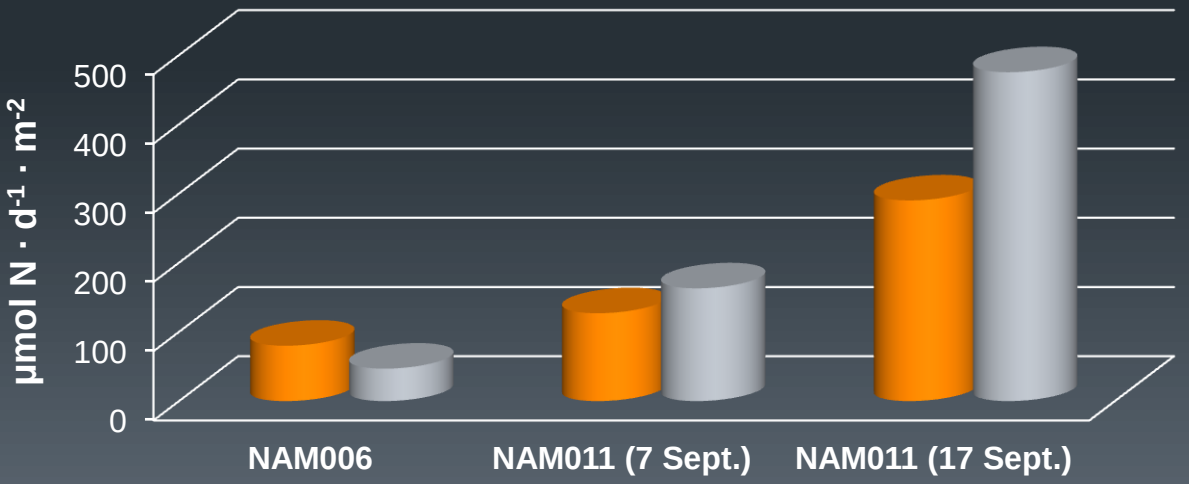
Nitrogen

Zooplankton

- Mooring data
- N flux model



Microplankton

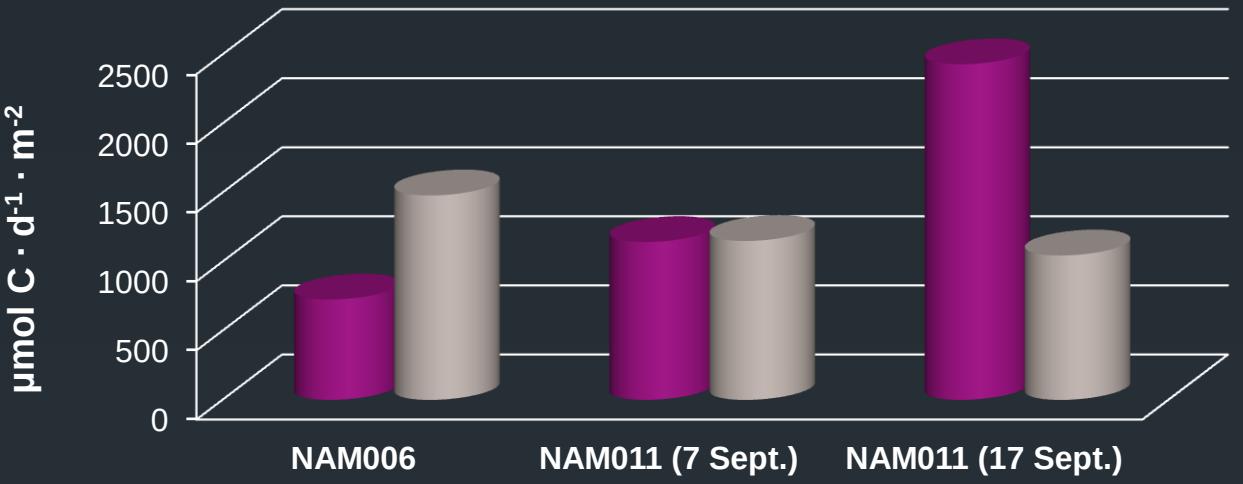


Results

Carbon

Zooplankton

- Mooring data
- C flux model



Microplankton